"TECH NOTES"

"TECH NOTES" is an effort by the FOSSC Materials Laboratory to share design and construction technology gained from projects done throughout WSDOT. This issue is from the Pavements Branch discussing Stone Matrix Asphalt (SMA).

Stone Matrix Asphalt (SMA)

"Stone Matrix Asphalt (SMA) is a tough, stable, rut-resistant mixture that relies on stone-on-stone contact to provide strength and a rich mortar binder to provide durability. These objectives are usually achieved with a gap-graded aggregate coupled with fiber or polymer modified, and high asphalt content matrix."[1]

The SMA mixture is composed of aggregate(s), mineral filler, asphalt cement and stabilizer (as necessary). The aggregate gradation for the SMA mixture is on the coarse side of the maximum density line on the 0.45 power chart compared to a dense graded mixture (Figure 1).

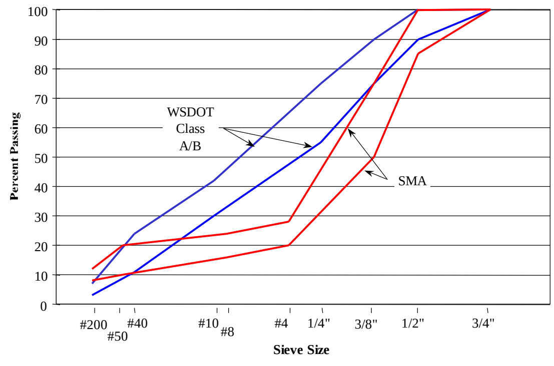

Figure 1. SMA vs. WSDOT Class A/B Gradation

Unlike an open-grade mixture, the majority of the voids between the coarse aggregates in an SMA mixture are filled with mineral filler and binder[2]. SMA is typically designed with an air void content between three and four percent. Too much asphalt will push the coarse aggregate particles apart with a drastic reduction in pavement shear deformation resistance. While too little matrix results in high air voids which reduces the pavement durability caused by accelerated aging and moisture damage[3].

In general, a SMA mixture contains approximately 10 percent minus #200 dust with a 1.5 dust to binder ratio. The high percentage of dust can easily be obtained in the laboratory, however an additional feed system may be needed at the hot-mix plant to introduce this high amount of mineral filler.

The aggregates must have (1) a highly cubic shape and rough texture to resist rutting and movements, (2) a hardness which can resist fracturing under heavy traffic loads, (3) a high resistance to polishing, and (4) a high resistance to abrasion[2].

Potential problems with SMA mixtures are drainage and bleeding. Storage and placement temperatures cannot be lowered to control drainage and bleeding problems due to the difficulty in obtaining the required compaction. Therefore, stabilizing additives such as fibers,

[1] "Designing and Constructing SMA Mixtures – State-of-the-Practice," Quality Improvement Series 122, National Asphalt Paving Association.

[2] "Stone Mastic Asphalt (SMA) Mixture Design", FHWA-RD-92-006, Federal Highway Administration, Turner-Fairbank Highway Research Center, McLean Virginia, March 1992.

[3] Dietz, Jason, M., "The Use and State of the Practice of Stone Matrix Asphalt", February 1997.

rubbers, polymers, Lake Trinidad asphalt, carbon black, artificial silica, or combinations of these materials have been added to stiffen the mastic at high temperatures and to obtain even higher binder contents for increased durability[2]. Fibers (cellulose and rock wool) are commonly used stabilizing additives. Based on aggregate gradation and type of asphalt binder used, it is possible that stabilizing additives may not be necessary. A draindown test procedure (AASHTO T305) has been developed to determine the SMA mixtures susceptibility to draindown.

Photo 1 illustrates the comparison of the aggregate structure for SMA mixtures to that of a WSDOT standard Class A/B mixture.

Photo 1a. SMA

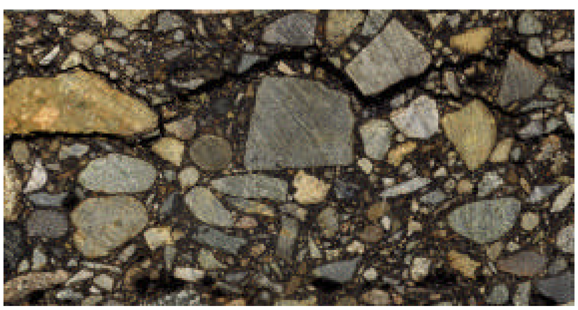

Photo 1b. WSDOT Class A/B

The SMA mixture is appropriate on pavements carrying heavy volumes of traffic or on pavements carrying heavy loads and/or high tire pressures. However, due to the stiffness of the mixture and the construction difficulties this brings, selected projects should have minimal utility adjustments or handwork requirements.

In order for SMA's to perform as expected, the following design, production and construction practices must be followed[1].

- Provide stone-on-stone contact through the selection of a proper gradation.
- Use hard, cubical, durable aggregate.
- Design at an asphalt content of at least six percent and air void content of four percent, for most mixtures.
- Design for voids in the mineral aggregate such that at least 17.0 percent is obtained during production.
- Check for and meet moisture susceptibility and draindown requirements.
- Proper design and control of SMA mixture (asphalt content, gradation, mineral filler, stabilizer, mixing temperature, and moisture).
- Maintain close control of plant stockpiles and cold feed.
- Maintain close control of plant temperatures.
- Maintain consistent paving speed and compaction effort.
- Use the necessary number of rollers to achieve a minimum density of 94 percent of maximum density.
- Avoid hand work whenever possible.
- Minimize the number and extent (size) of fat spots that appear behind the paver.
- Use good quality assurance practices including frequent monitoring of all aspects of production, paving and compaction.

WSDOT's first SMA was constructed as an overlay project in the Northwest Region, within the Lynnwood city limits. This section of highway is an urban principle arterial with an ADT of approximately 16,000 with three percent trucks. The overlay depth for the 12.5 mm (nominal maximum aggregate size) SMA was 45 mm. The total amount of SMA to be placed was approximately 5,800 tons. Typical roadway conditions prior to placement of the SMA are shown in Photo’s 2 and 3.

Photo 2. Intersection rutting.

Photo 3. Typical alligator cracking.

Photo 4 illustrates the surface texture of the SMA mixture and Photo 5 illustrates the SMA’s susceptibility of fat spots due to draindown.

Photo 4. SMA surface.

Photo 5. Fat spots due to drain-down.

The following is a list of lessons learned from the first SMA project constructed in Washington State.

- Adequate field study is required to ensure that SMA is being placed on sound, stable material (this was demonstrated at the 44^{th} Street intersection where unstable ACP was known to exist and the SMA after one year, in this location only, is starting to rut).
- Clearly define which specific gravity will be used in the design process.
- The three trial blends must be provided with the mix design recommendations, such that any changes in the mix gradation can be more clearly understood.
- Multiple stockpiles are necessary.
- Separate silo and feed systems are necessary for controlling the amount of mineral filler and stabilizing fibers.
- Plant production temperature must be achieved and maintained to minimize the draindown.
- Inspection and certification of the plant prior to approval.
- Use greased metal buckets for storing mix samples.
- Need to be very diligent in cleaning the equipment.
- Do not run conveyors on paving machine or material transfer device empty. This leads to excessive draindown due to the build up of excess oil in the MTV.
- Keep paver moving, excessive

stopping and starting may lead to cooling of mix and result in inadequate temperatures for compaction.

- Ensure tack coat has cured prior to paving to minimize the amount of material picked up by delivery trucks.
- Consider the use of insulated trucks and/or tarped trucks to minimize the cooling of the mixture.
- Make sure contractor's compaction personnel are trained and aware of the special needs to keep the compaction train closer to the paver. Aggressive compaction is necessary especially with the breakdown roller.
- Have a good location for trucks to clean out their beds, and stress that fuel oil "NOT" be used. This could also cause excessive draindown.
- Construction must not proceed without an approved mix design procedure.
- Conformance with Special Provision must be obtained and monitored.
- Ensure communication between the state and contractor.

It was anticipated, due to the small quantity of SMA and the newness of the SMA technology in Washington State, that the bid price for SMA would be substantially higher than the estimated 20 to 25 percent increase in cost over traditional dense graded mix. This project had three bids submitted by local contractors with a range in SMA mix costs of $57.50 to $72.50 per metric tonne ($52.16 to $65.77 ton). The average mix price for WSDOT ACP Class A in the vicinity of the SMA project is $34.25 per ton (price based on projects with 4,500 to 7,400 tons of ACP Class A). The successful bidder had a cost of $65.77 per ton, which is approximately 92 percent higher than WSDOT ACP Class A.

Based on the results of this first SMA project a number of modifications were made to the SMA Special Provisions that incorporate the lessons learned as well as information provided from the National Asphalt Paving Association (NAPA) and the National Center for Asphalt Technology (NCAT). A Tech Note summarizing the second SMA will be available Spring 2001.

A complete research report has been prepared on this first SMA project and can be obtained from the WSDOT Research Office or from the contact provided below.

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